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Noda et al.

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(54) **MASS SPECTROMETER**

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(51) **Int. Cl.**
H01J 49/00 (2006.01)

(52) **U.S. Cl.**
USPC **250/281**; 250/288; 361/818

(58) **Field of Classification Search**
USPC 250/281
See application file for complete search history.

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(57) **ABSTRACT**

In the spectrometer, heavy loads are arranged centrally inside a case having a height smaller than a width, and having a depth smaller than the height. The heavy loads include a vacuum chamber, a vacuum pump which evacuates the vacuum chamber, a sample introduction unit which introduces a sample to be measured and evaporates the sample, an ionization unit which ionizes the evaporated sample and provides it to the vacuum chamber, and an ion detection unit which is connected to the vacuum chamber. Circuit board storage units which store a plurality of circuit boards with a predetermined space therebetween are formed on both sides along a width direction of the case.

12 Claims, 6 Drawing Sheets

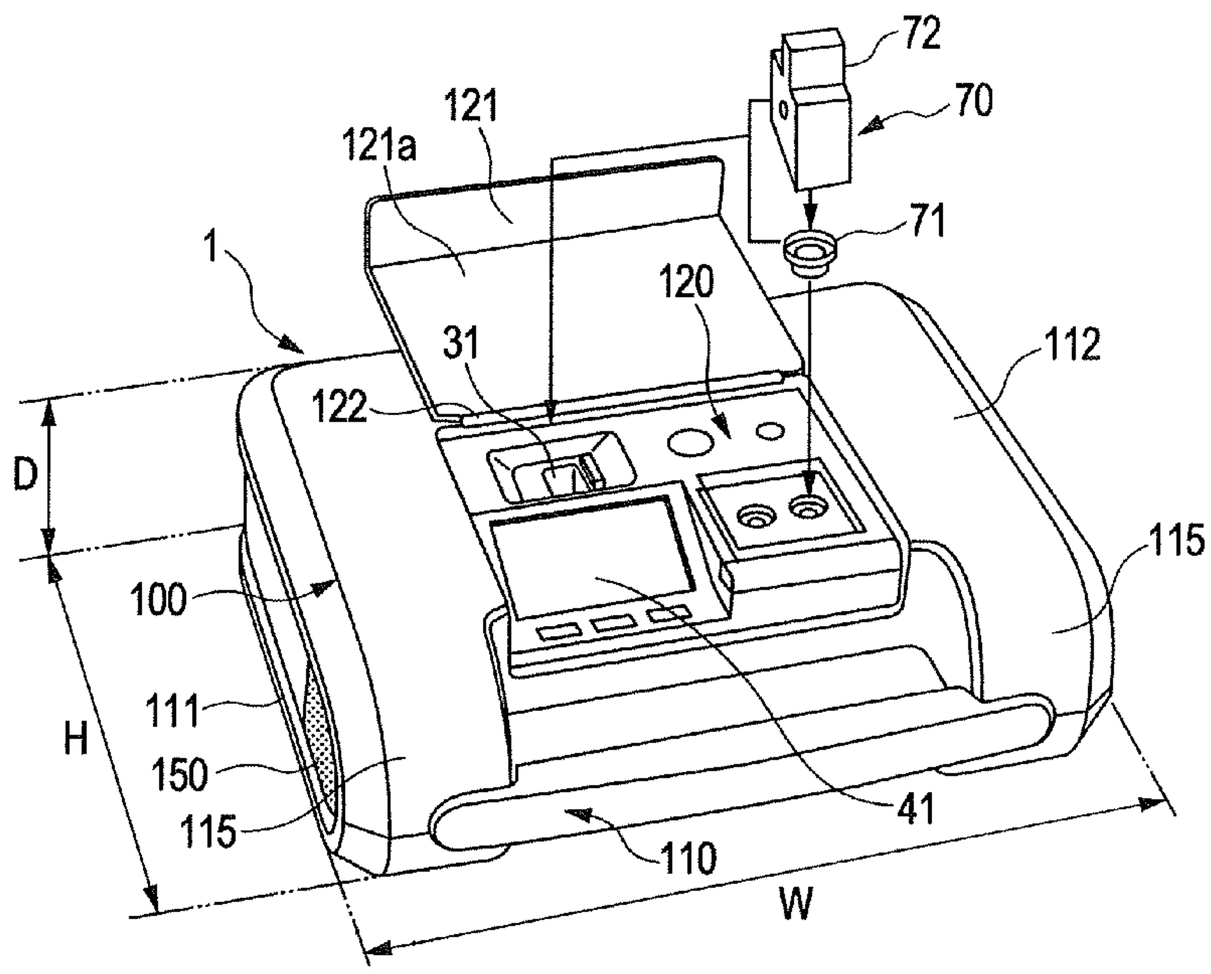


FIG. 1A

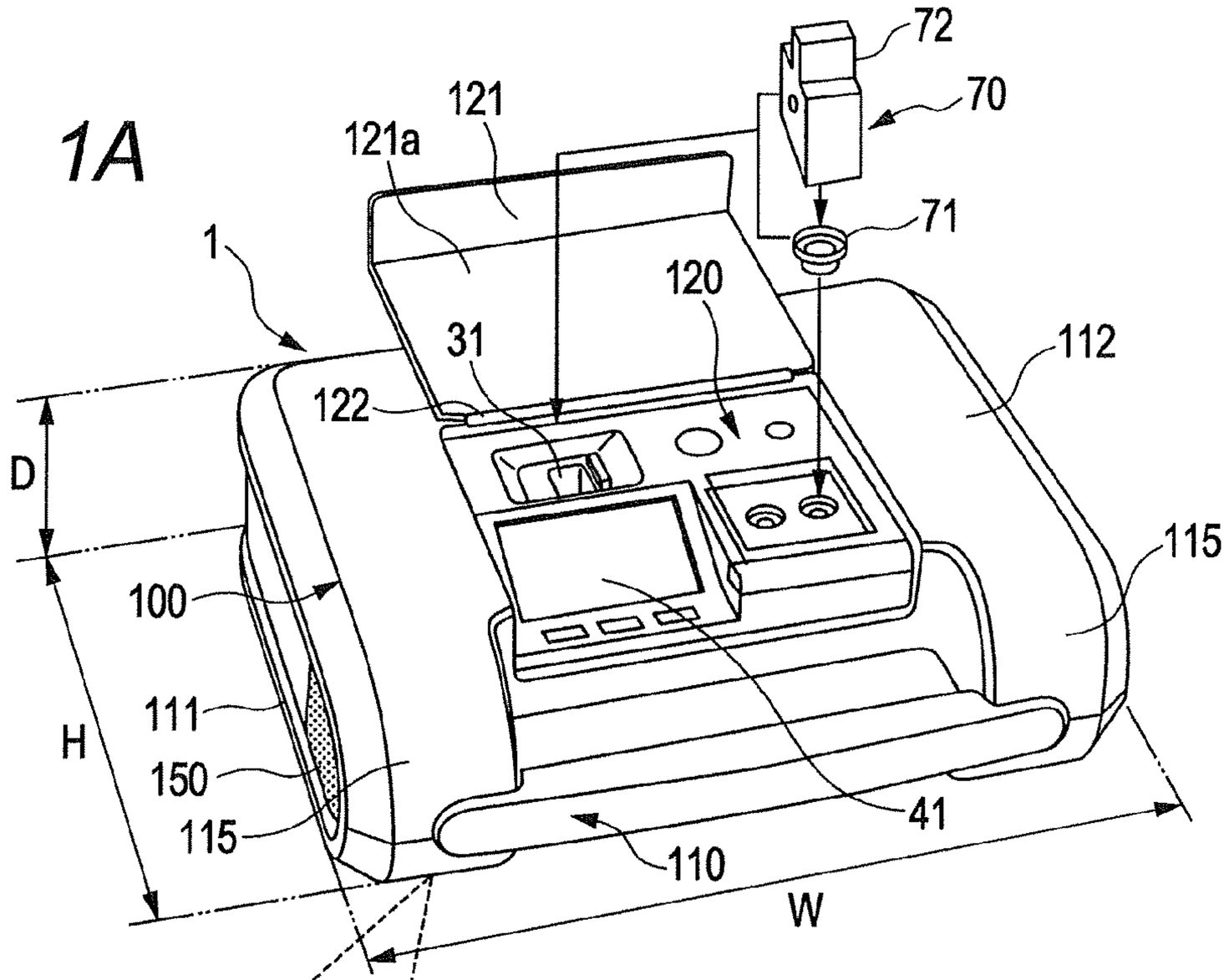

72
70
121
121a
71
1
120
31
112
122
D
115
100
111
H
150
115
41
110
W

FIG. 1B

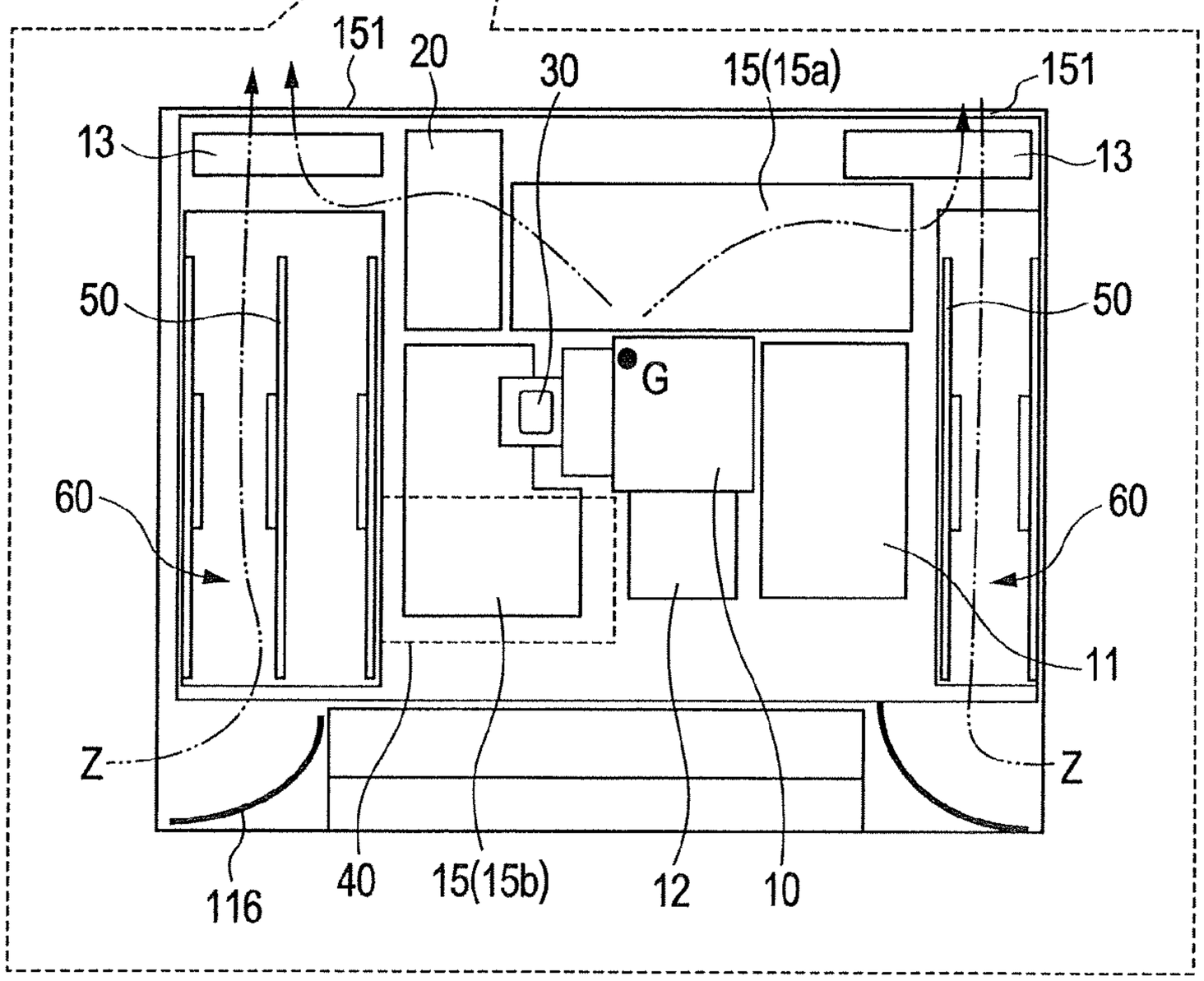

151
20
30
15(15a)
151
13
13
50
50
G
60
60
11
Z
Z
116
40
15(15b)
12
10

FIG. 2A

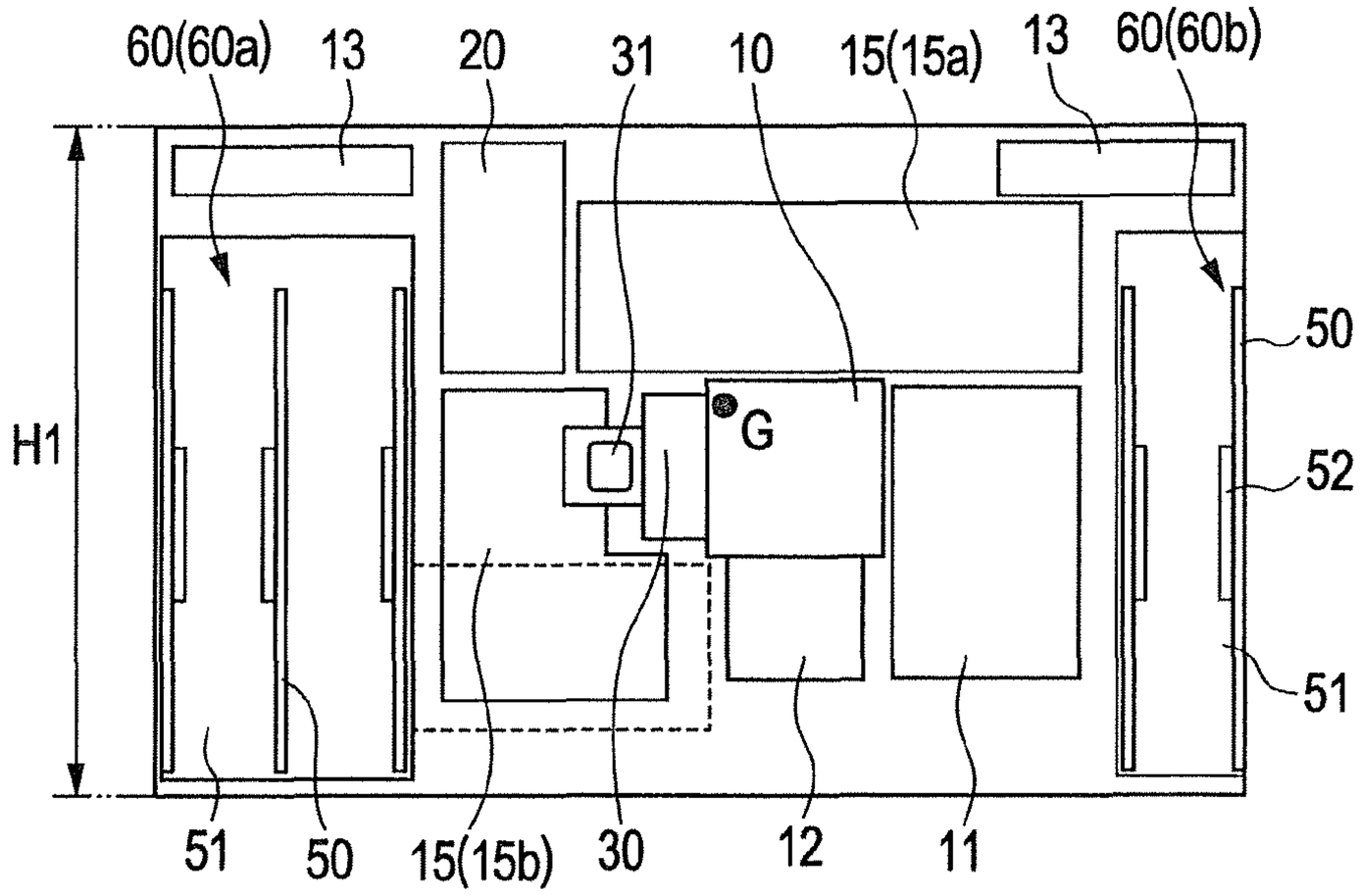


FIG. 2B

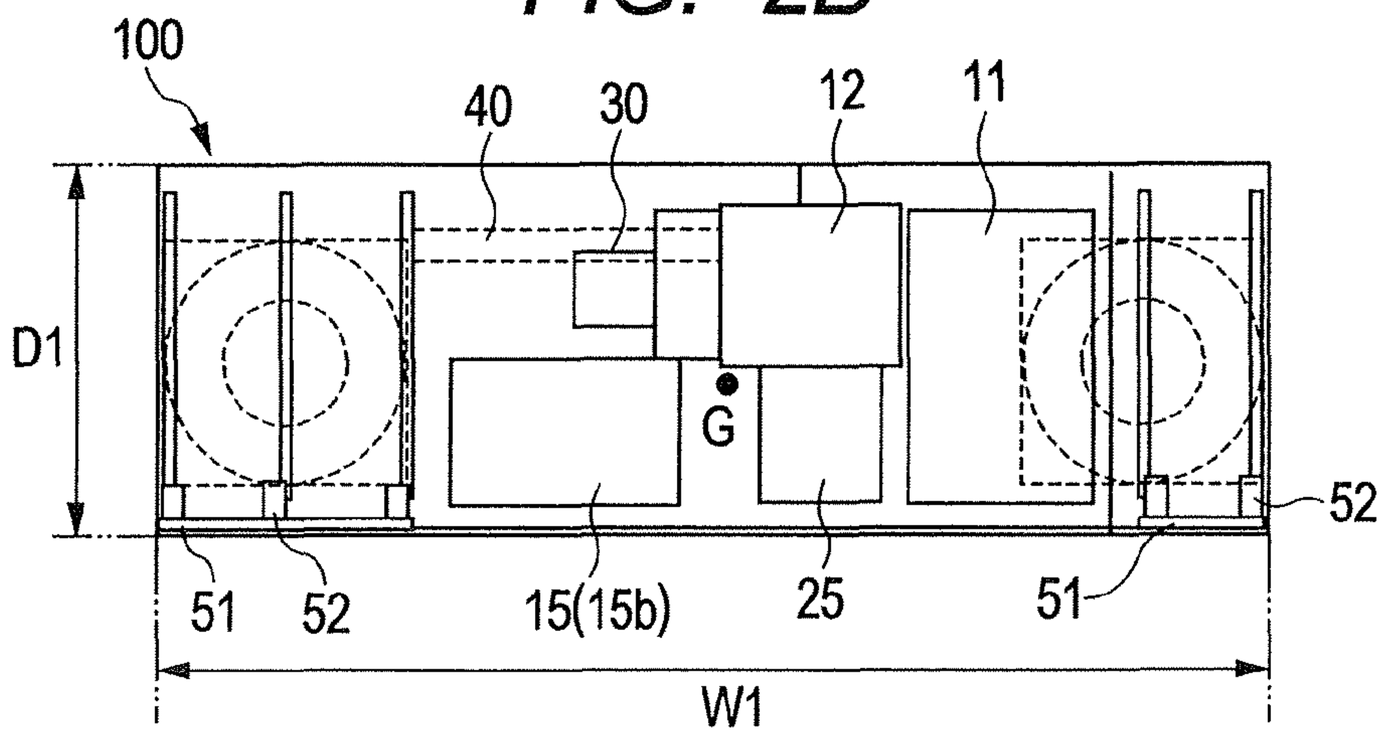


FIG. 2C

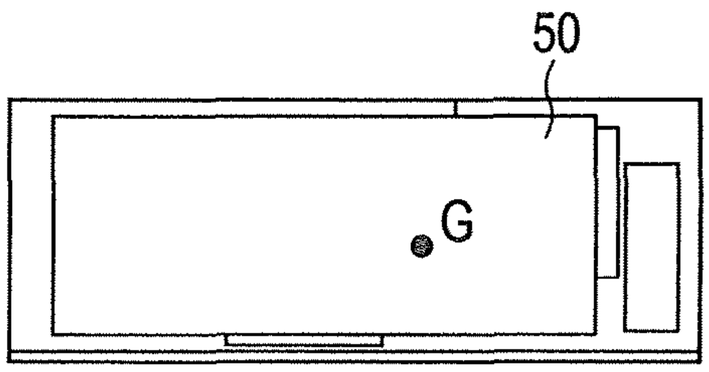


FIG. 3

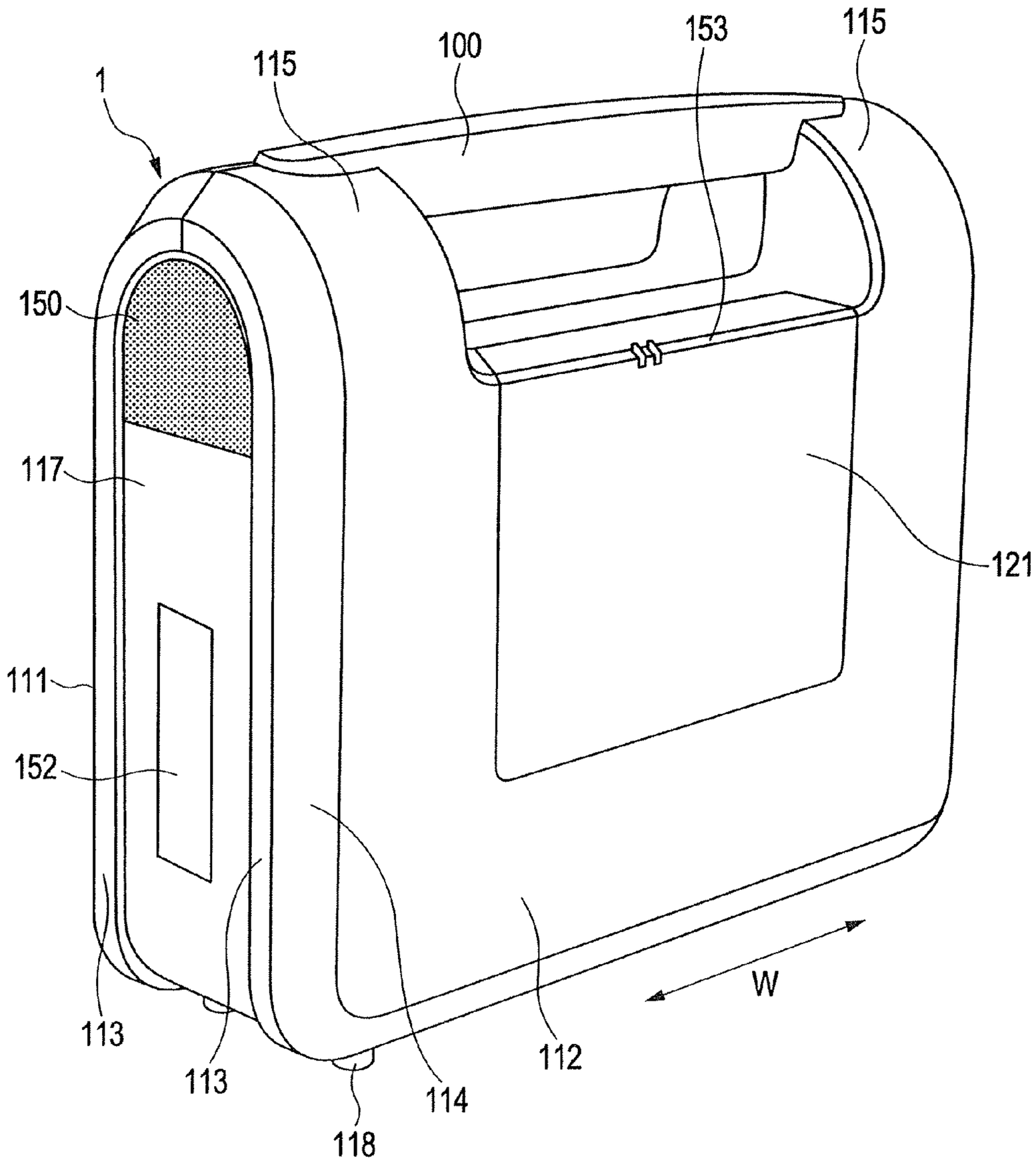


FIG. 4

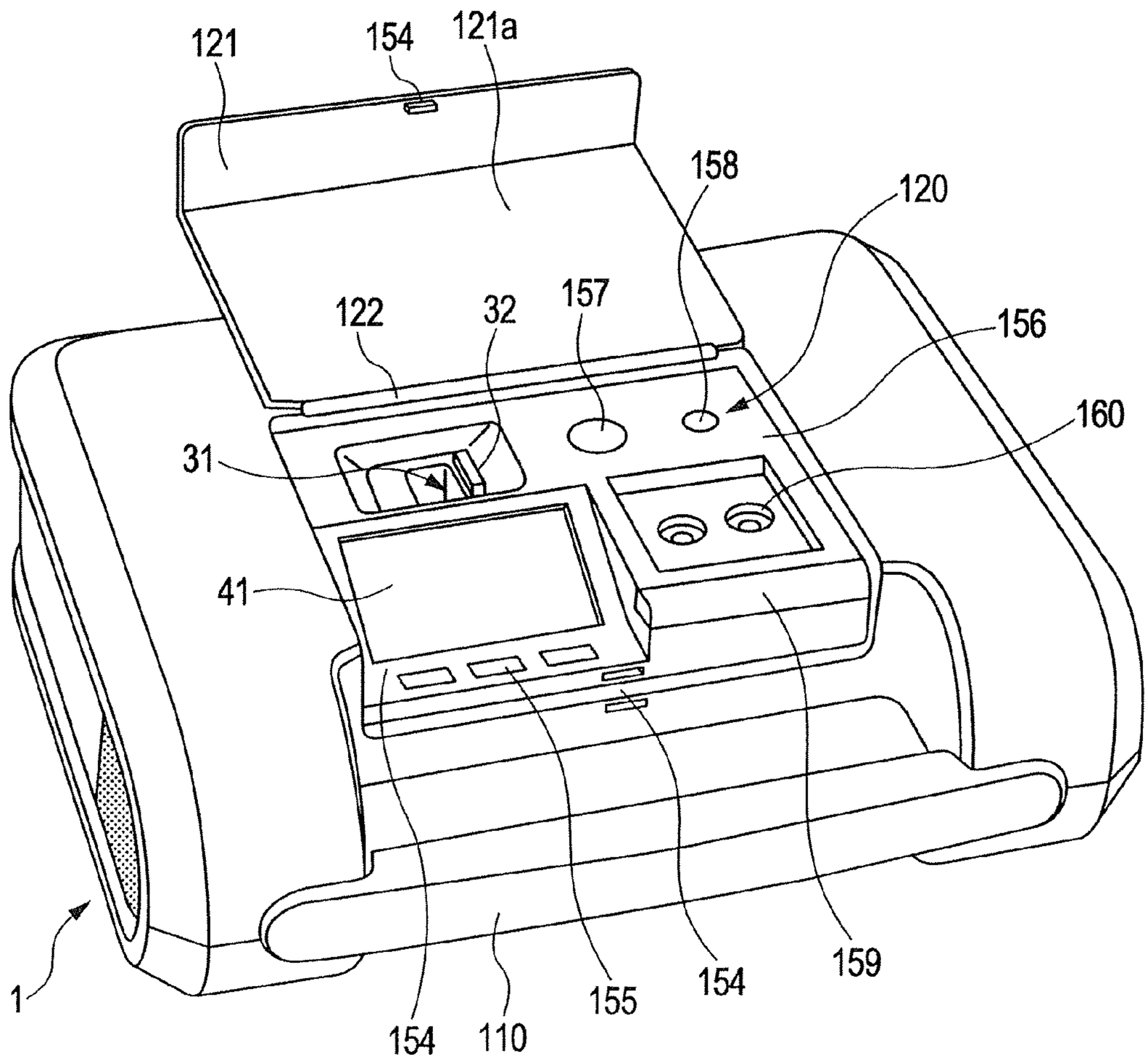

121
154
121a
158
120
122
32
157
156
160
31
41
159
1
154
110
155
154

FIG. 5A

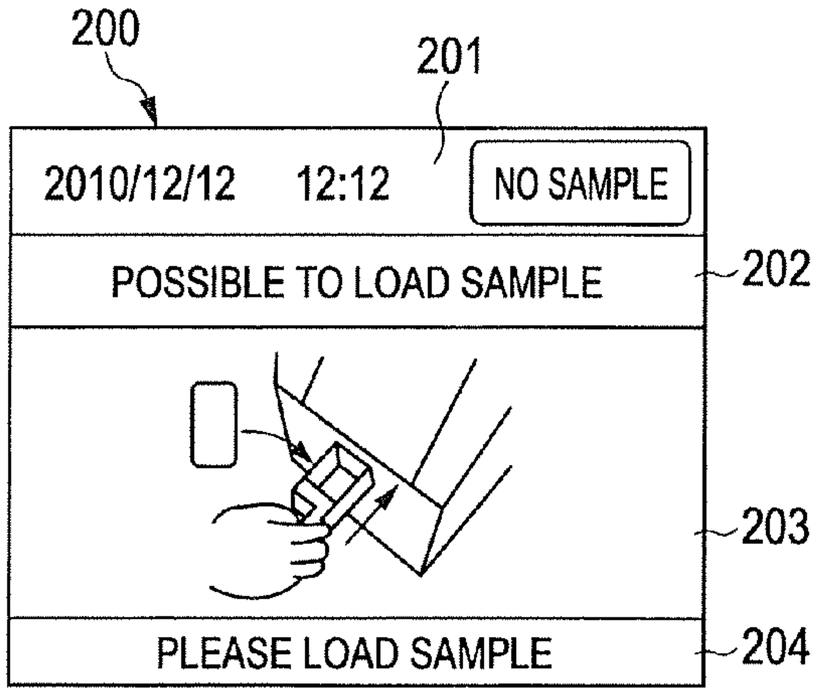


FIG. 5B

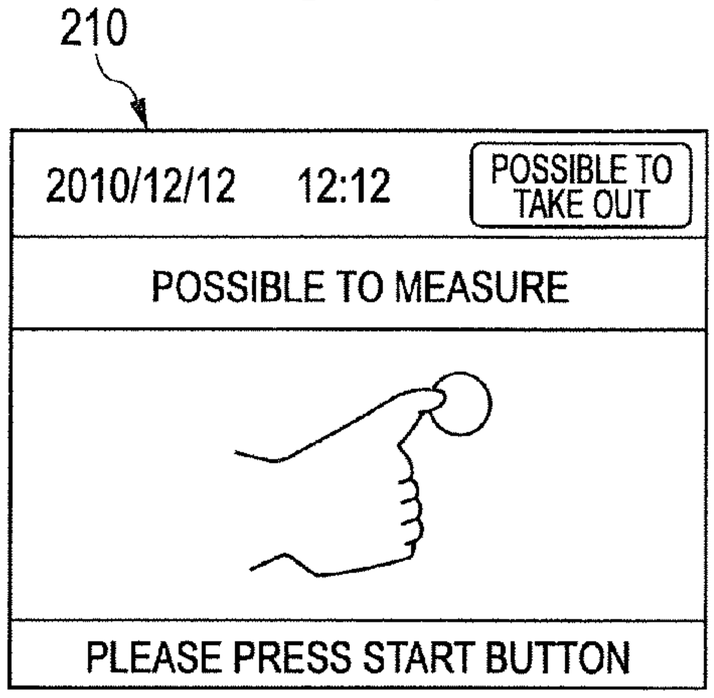


FIG. 5C

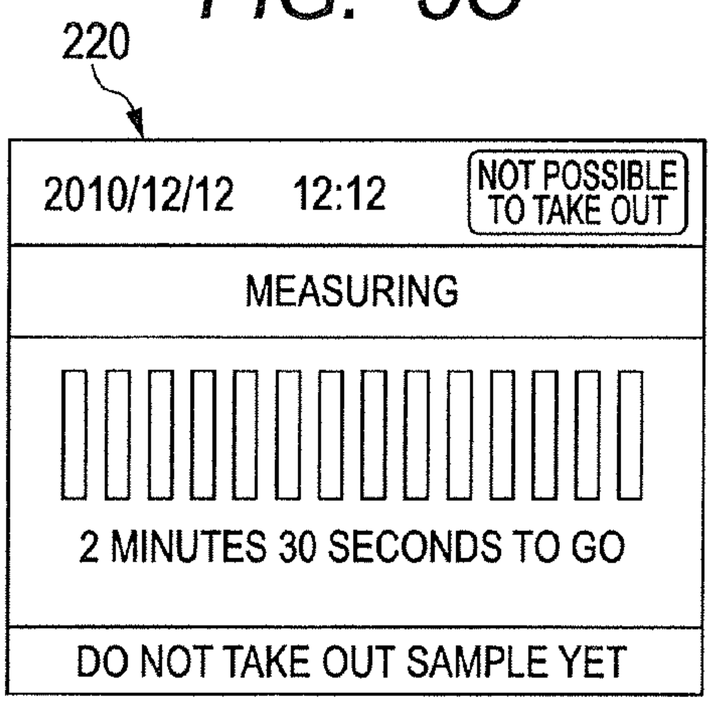


FIG. 5D

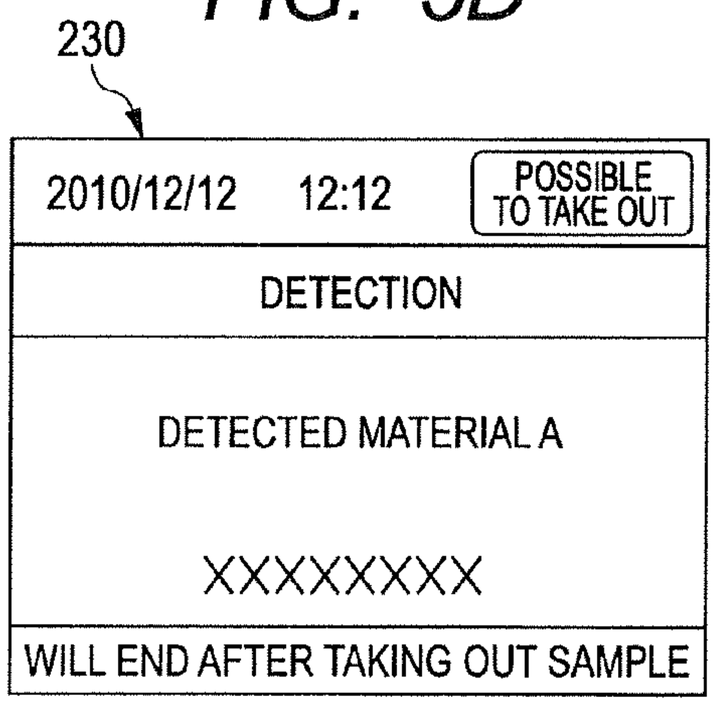


FIG. 5E

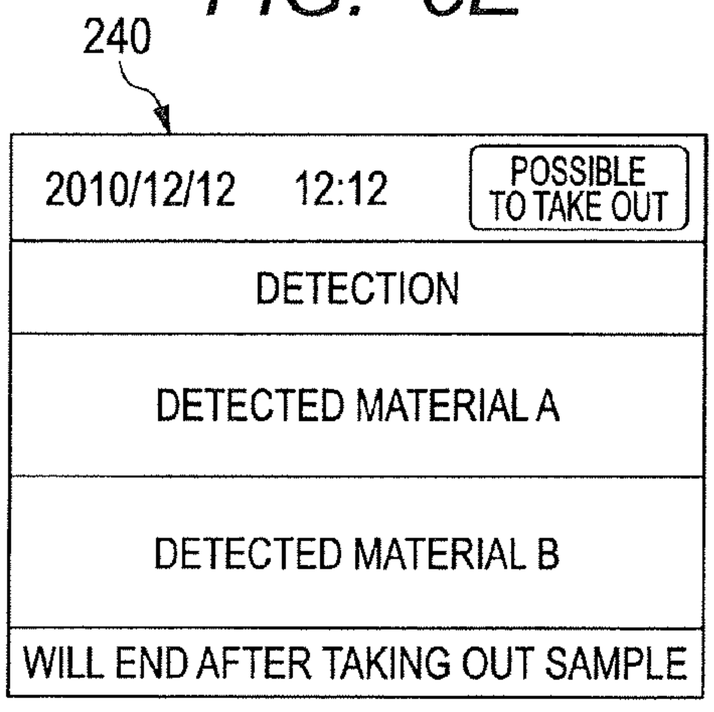


FIG. 5F

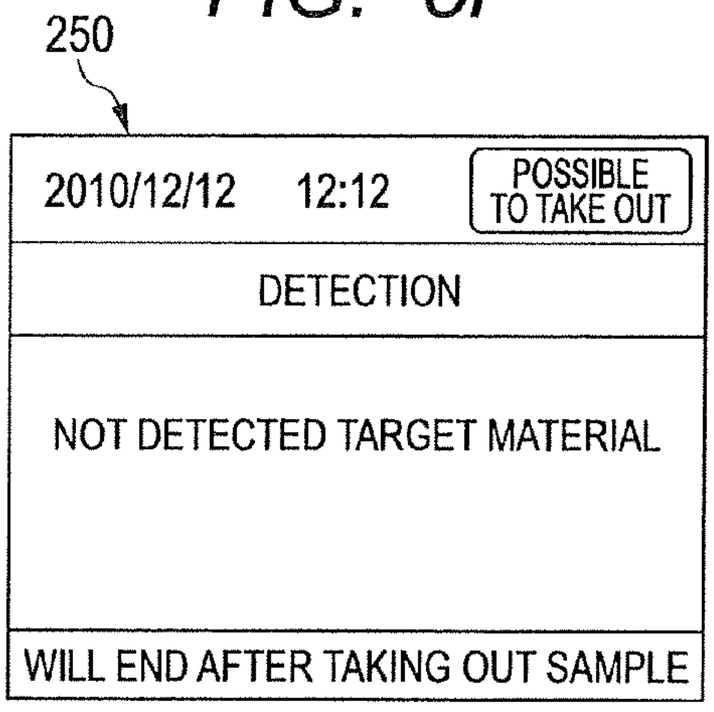


FIG. 6A

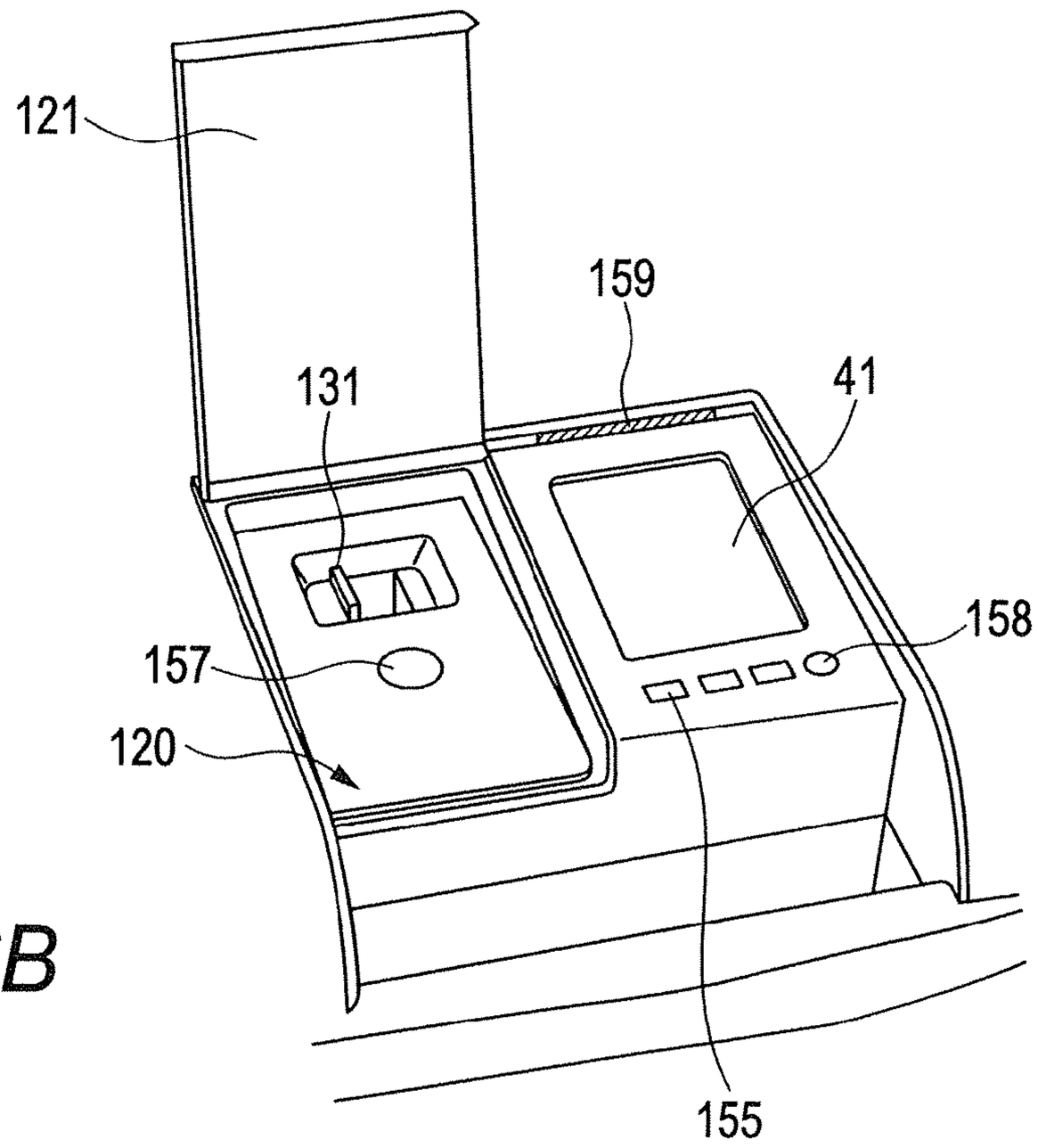
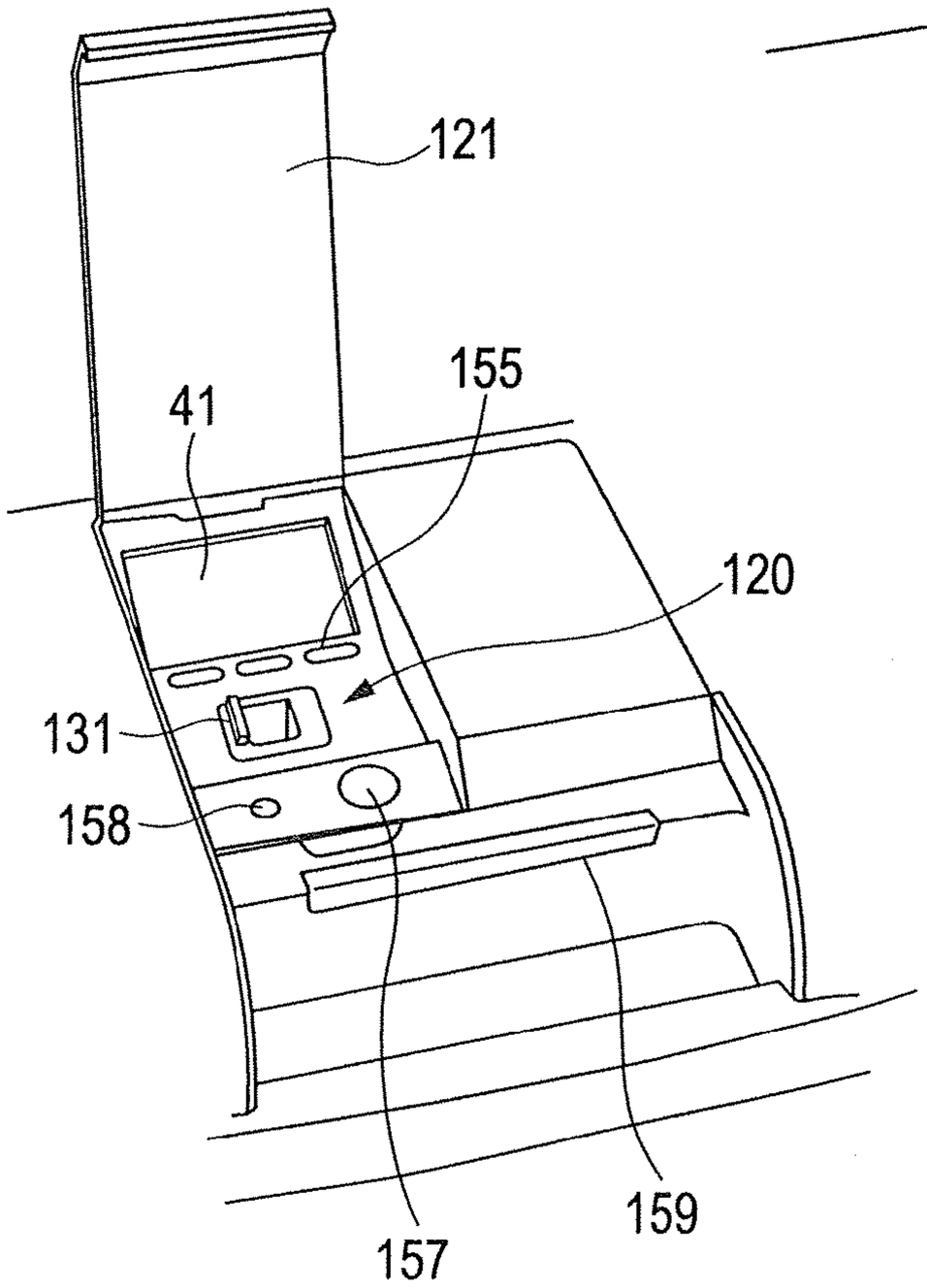


FIG. 6B



MASS SPECTROMETER

CLAIM OF PRIORITY

The present application claims priority from Japanese patent application JP 2011-079623 filed on Mar. 31, 2011, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a small mass spectrometer.

2. Description of the Related Arts

Well-known mass spectrometers ionize a small volume of samples and electomagnetically separate the ions, thereby reliably measuring molecular weights. The mass spectrometry includes a liquid chromatography mass spectrometry and a chromatography mass spectrometry. The liquid chromatography mass spectrometry includes mass spectrometry after separating components of a target material to be analyzed in liquid chromatograph, while the chromatograph mass spectrometry includes qualitative analysis of the same component separated in gas chromatograph by performing the mass spectrometry measuring, so as to determine the quantitation of the components based on the intensity of the ion detected by the mass spectrometry.

In recent years, introduction of mass spectrometers has been demanded for the sake of safety, in some kinds of environments, such as the industry, the non-official entities, and military environment. This is because it is necessary to quickly determine the level or kind of contamination due to unknown chemical goods as quickly as possible.

Particularly, in some well-known cases, the introduction of the mass spectrometer has been demanded as a countermeasure for terrorism using chemical weapons (for example, poisonous gas) or for maintaining strict control of drugs. However, the conventional mass spectrometers are too large to be carried.

Some conventional techniques have been proposed. One technique (Japanese Patent Application Laid-Open Publication No. 2003-294619(hereinafter referred to as Patent Document 1)) proposes a portable compound analyzing system having a portable case containing at least an optical spectrometer and a mass spectrometer. Another technique (Japanese Unexamined Patent Application Publication No. 2003-527563 (hereinafter referred to as Patent Document 2)) proposes a gas chromatograph mass spectrometer whose entire weight including the entire vacuum system is light to be carried (approximately 25 kg).

SUMMARY OF THE INVENTION

The conventional technique discloses a method for improving the portability by storing internal implementation units inside a rectangular parallelepiped. However, such conventional techniques make no attention to the weight balance nor a problem about heat exhaustion at the implementation. This weight balance is an important matter to be considered in carriage.

For example, the first conventional example (Patent Document 1) has a layout in which entrances/exits respectively for an optical analyzing unit, a mass spectrometer, and an optical sound analyzing unit are about to face each other in adjacent positions, in consideration that the total length of the piping for conducting sample gas to each analyzing unit. Therefore, the disclosure contents make no attention to the weight balance, and do not disclose heat exhaustion.

The second conventional example (Patent Document 2) discloses a technique: for specifying various units included in the mass spectrometer; for setting the inside measurement of approximately 0.09 cubic meter; and for decreasing the inside measurement by having a suitable layout. However, no disclosure has been made to a basic layout or specific contents therefor and to heat exhaustion.

An object of the present invention is to provide a small size mass spectrometer which realizes excellent heat exhaustion efficiency and which is weight balanced in carriage.

In order to attain the above object, according to an aspect of the present invention, there is provided a mass spectrometer including a case and circuit board storage units which store plural circuit boards on both sides of the case, the case having heavy loads including a vacuum chamber, a vacuum pump which evacuates the vacuum chamber, an ion detection unit which is connected to the vacuum chamber, and a battery.

According to this invention, it is possible to provide a small mass spectrometer which realizes excellent heat exhaustion efficiency and good weight balance, because the weight balance is adjusted, by setting the circuit board storage units as exhaust passage, by centrally arranging the heavy loads, and by arranging two groups of light weighted boards on both sides thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic block diagram of a mass spectrometer according to the present invention;

FIG. **1**B is a schematic block diagram of the mass spectrometer according to the present invention;

FIG. **2**A is an internal layout diagram of the mass spectrometer according to the present invention;

FIG. **2**B is an internal layout diagram of the mass spectrometer according to the present invention;

FIG. **2**C is an internal layout diagram of the mass spectrometer according to the present invention;

FIG. **3** is an appearance diagram of the mass spectrometer when it is carried, according to the present invention;

FIG. **4** is an appearance diagram of the mass spectrometer when it is used, according to the present invention;

FIG. **5**A to FIG. **5**F are screen transition diagrams of the mass spectrometer according to the present invention;

FIG. **6**A is a diagram of a mass spectrometer according to another embodiment of the present invention; and

FIG. **6**B is a diagram of the mass spectrometer according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Descriptions will now specifically be made to a mass spectrometer according to this invention, with reference to FIGS. **1**A to **6**B. FIGS. **1**A to **5**F illustrate the mass spectrometer according to a first embodiment, while FIGS. **6**A and **6**B illustrate a mass spectrometer according to another embodiment. In the descriptions below, the same components and arrows are identified by the same symbols, and will be described once.

First Embodiment

The schematic configuration of the mass spectrometer according to this invention will now be described with reference to FIGS. **1**A and **1**B. FIG. **1**A shows the appearance

diagram of the mass spectrometer, while FIG. **1**B shows the layout of the component parts inside the spectrometer.

In FIGS. **1**A and **1**B, the symbolical numeral **1** generally identifies the portable mass spectrometer which ionizes a small volume of sample and detects components of the sample by electromagnetically separating the ions.

This mass spectrometer **1** includes some mounted components, such as a vacuum chamber **10** and a vacuum pump **15**, that are contained inside a box-type case **100**. The appearance diagram of FIG. **1**A shows a usage state (detection state) of the spectrometer which can be carried by a user holding a handle unit **110**. The case **100** of this embodiment has a height H smaller than a width W, and has a depth D smaller than the height H. In addition, the case **100** has a size of a small bag, thus is excellent in carriage. That is, the user holding the handle unit **110** can carry the mass spectrometer **1** without a sense of discomfort.

As illustrated in FIG. **1**A, at the usage, on this case **100**, one wide surface **111** comes into contact with the installation surface, and an operation unit **120** is provided on the other wide surface **112** as the upper surface. This operation unit **120** is used for executing a detection operation. Thus, the user can use the securely installed mass spectrometer to perform the detection.

One major characteristic of the mass spectrometer of this embodiment is that the heavy loads, such as the vacuum chamber **10** and the vacuum pump **15**, are arranged centrally inside the case **100**, and plural circuit boards **50** are arranged on both right and left sides thereof.

In the example of FIG. **1**B, three circuit boards are arranged on the left side of the illustration paper, while two circuit boards are arranged on the right side thereof.

That is, when the small size mass spectrometer **1** is carried, it is preferred that it be weight balanced. It is also preferred that the heavy loads be arranged near and right under the handle unit. For example, when to carry a bag having the heavy loads put aside to one side of the bag, this bag is not weight balanced, thus is not easily handled. In this case, a large moment is applied to the handle in carriage. This requires large power just to carry the bag.

The above problems are applicable to a bag having one single handle in the center of the top surface of the bag and also to a bag having handles on both sides thereof. That is, as a small size mass spectrometer, it is preferred that the spectrometer be weight balanced with the center of gravity near the center of the base **100**.

In consideration of the above, inventors of the present invention paid their attention to a point that the mass spectrometer **1** needs plural circuit boards **50** and a point that the circuit boards **50** are used as a unit for improving the weight balance. The weight of the circuit boards **50** is very small in relation to their packaging space inside the case **100**. On the contrary, the vacuum chamber **10**, the vacuum pump **15**, and a battery **20** are the heavy loads. Therefore, their arrangement has a great effect on the weight balance.

According to the given layout of this embodiment, the vacuum chamber **10** and the vacuum pump **15** are centrally arranged in the case **100**, and the plural circuit boards **50** are arranged on both sides thereof.

In general, in relatively large bags (business case) that are carried with a single hand, the width W along the front and rear direction of the user when holding the bag with one single hand is greater than the height H along the vertical direction when holding the bag with one hand. This setting is made for not bothering about obstacle on the floor, in order that the width direction (width W) while walking coincides with the direction in which the user swings his/her arms as he/she walks, and in order to notice any obstacle on the front. Further, when holding the bag with one single hand, it is easy to hold the bag having the center of gravity right under the shoulder. Based on this, the width direction (depth W) of the user should be made thin so that the user can easily hold the bag. That is, it can be said that the portability can be maintained even if the width W is made large, in this type of one-hand-holding bag.

The inventors of the present invention have employed a layout in which the circuit boards **50** are arranged on both sides of the width W as the width direction, when holding the bag with one hand. Besides, the circuit boards **50** can easily be divided in the unit of several boards **50** and in the unit of functions. The plural separated circuit boards **50** can easily be arranged on both sides in consideration of the weight balance, thus capable of easily adjusting the center of gravity in the center of the case **100**.

Another major characteristic of the mass spectrometer of this embodiment is that the heavy loads are arranged in the center of the case **100** round the vacuum chamber **10**.

That is, in the mass spectrometer **1**, a sample insertion unit **30**, the vacuum pump **15**, and the ion detection unit **25** are connected to the vacuum chamber **10** (see FIGS. **2**A to **2**C). According to an employed layout of this embodiment, the vacuum chamber **10** is arranged in the center of the case **100**, and various units are arranged therearound. In this configuration, the heavy loads can easily be arranged in the center of the case **100**. Besides, the length of the electrical wiring can be made short, because the circuit boards **50** are arranged on both sides thereof.

In this embodiment, the vacuum chamber **10** is put aside to one wide surface **112** of the case **100**, as its upper surface at the usage state shown in FIG. **1**A. In addition, the sample insertion unit **30** and an RF oscillation circuit unit **11** are arranged to face each other, and a first vacuum pump (turbo pump) **15***a* and a vacuum gage unit **12** are arranged to face each other, on the side surface around the chamber. Further, the ion detection unit **25** (see FIGS. **2**A to **2**C) is arranged on the bottom surface. With this configuration, the sample insertion unit **30** connected to the vacuum chamber **10** can be arranged near the wide surface **112**, thus easily attaching a sample insertion adapter **70** to the sample insertion unit **30**.

Further, the weight balance is improved by arranging a heavy second pump (roughing vacuum pump) **15***b* on the opposite side of a heavy first vacuum pump **15***a*, through the vacuum chamber **10**. A liquid crystal display unit **40** is arranged on the upper surface of the second vacuum pump **15***b*, and this liquid crystal display unit **40** is arranged adjacent to the sample insertion unit **30**. As a result, an operation unit **120** including the sample insertion unit **30** and the liquid crystal display unit **40** is arranged on the upper wide surface **112**.

Still another major characteristic of the mass spectrometer according to this embodiment is that the circuit boards **50** with high consumption power and generating heat are arranged near the right and left ends of the case, and circuit board storage units **60** on both sides thereof are exhaust heat passages.

That is, if each unit included in the mass spectrometer **1** is made compact, it is necessary to exhaust heat generated from each unit efficiently outside the case **100**. In this embodiment, therefore, the circuit board storage units **60** are used as an exhaust heat passage of the circuit boards **50** arranged on both sides of the case **100**. The circuit board storage units **60** as the exhaust heat passage are provided on both sides of the case **100**. Thus, the heat generated by the circuit boards **50** can

efficiently be exhausted using the two circuit board storage units **60**. Because the circuit boards **50** are arranged along the exhaust passages, the heat generated by the circuit boards **50** is not conducted to the vacuum chamber or RF circuit, thus restraining the change in the performance of each unit due to temperature rise.

Still yet another major characteristic of the mass spectrometer **1** of this embodiment is that the circuit boards **50** provided in the circuit board storage units **60** are aligned along an exhaust passage direction Z.

That is, in this embodiment, in the configuration of the circuit boards **50**, they are divided in the unit of several circuit boards **50** and arranged on both sides of the case **100**, so as to improve the weight balance. However, the circuit boards **50** to be divided in the unit of several circuit boards needs to have certain sizes, otherwise the efficiency decreases. In this embodiment, one single circuit board **50** is rectangular, in which one side (long side) is equal to or smaller than the height H, another side (short side) is equal to or smaller than the depth D, and the thin thickness direction is parallel to the width direction W.

According to the arrangement of the circuit boards **50** in the circuit board storage units **60**, one sheet of circuit board **50** can be made large, and each of the circuit board storage units **60** may be an aggregation of the plural circuit boards **50**. In this case, each of the circuit board storage units **60** has spaces that are long along the height H and separated by the circuit boards **50**. Therefore, in this embodiment, an exhaust passage along the exhaust passage direction Z (same as the height H) is formed inside the unit **60**.

In this embodiment, to improve the exhaust efficiency, a blast fan **13** is arranged on one of the circuit board storage units **60** as the exhaust passage. In this embodiment, exhaust ports **150** are provided on both side surfaces of the case **100** as both sides of the handle unit **110**, while an inlet port **151** is provided on the back surface side (bottom surface side) of the case **100** facing the handle unit **110**.

Further major characteristic of the mass spectrometer **1** of this embodiment is the compact appearance structure in accordance with the internal configuration.

That is, in the appearance of the case **100** of this embodiment, both ends of the case **100** covering the circuit board storage unit **60** are projected in the forward direction, and the bar-like handle unit **110** is formed to connect the both ends of projecting units **115**. According to this configuration, the bar-like handle unit **110** can be incorporated with the case **100** so as to enhance the strength.

In this embodiment, exhaust wind-direction plates **116** are provided inside the pair of projecting units **115**, thereby refracting the exhaust. This avoids the exhaust from striking on the user. However, the present invention is not limited to the above configuration. For example, the space of the projecting units **115** may be used for storing attachments, or may be used as a packaging space for arranging the blast fan **13** or the circuit board **50**. The directions of the exhaust passage direction Z may be changed by switching the exhaust port **150** and the inlet port **151** from one to the other.

Still further major characteristic of the mass spectrometer **1** of this embodiment is that an opening/closing cover **121** is provided on the operation unit **120**, a non-illustrative manual is put on an internal surface **121***a* of the opening/closing cover, or the internal surface **121***a* is used as a storage space for the operation manual.

That is, the mass spectrometer **1** of this embodiment may frequently be carried outside. Thus, it is necessary to prevent dust from entering a sample insertion port **31** of the sample insertion unit **30** arranged inside the operation unit **120**, and to prevent any attacks on a display screen **41** of the liquid crystal display unit **40**. Hence, in the configuration of this embodiment, the operation unit **120** is covered with the opening/closing cover **121**. This opening/closing cover **121** includes a hinge **122** on a side facing the handle unit **110**, as illustrated in FIG. **1**. At the usage state, the opening/closing cover **121** may turn backward.

According to this configuration, the opening/closing cover **121** may be used not only as a protection unit for the spectrometer, but also as an attachment space for the operation manual on the internal surface **121***a*.

Descriptions will now further be made to the mass spectrometer according to this embodiment with reference to FIGS. **1**A to **5**F. FIGS. **2**A to **2**C are internal layout diagrams of the mass spectrometer according to the present invention. In particular, FIG. **2**A is a plane view of the mass spectrometer, FIG. **2**B is a front view of the mass spectrometer, and FIG. **2**C is a front view of the mass spectrometer. FIG. **3** is an appearance diagram of the mass spectrometer when it is carried. FIG. **4** is an appearance diagram of the mass spectrometer, at the usage. FIG. **5** are screen transmission diagrams of the mass spectrometer.

FIGS. **2**A to **2**C show the layout of the main constituent parts of the mass spectrometer according to this embodiment. In FIG. **2**A, the handle unit **110** is arranged in the lower part of the illustration. The internal constituent parts are attached to a non-illustrative chassis.

According to the configuration of this embodiment, the internal constituent parts are covered with a resin-formed outer case. In this embodiment, descriptions will be made to a configuration in which the internal constituent parts are covered with an outer case including the handle unit **110**. Instead of this outer case, the mass spectrometer may be carried while being stored in an attaché case including a hard case or may be stored in a soft (soft member) case including a handle part and a shoulder belt for holding the mass spectrometer contained in a box-type case.

In the descriptions of FIGS. **2**A to **2**C, to clarify the arrangement relationship of the units, the arrangement of each illustration will be described based on FIG. **2**B, on the assumption that the upper part of the illustration corresponds to the upper surface of the spectrometer.

As described above, in this embodiment, the heavy loads are concentrated in the center of the case **100**, and the circuit board storage units **60** including the circuit boards **50** are provided on both sides thereof. The main unit of the heavy loads is the vacuum chamber **10**. This vacuum chamber **10** is arranged in the upper central part of the case **100**.

In the plane view of FIG. **2**A, the sample insertion unit **30** and the RF oscillation circuit **11** are arranged to face each other on both sides of the vacuum chamber **10**. The vacuum gate unit **12** and the first vacuum pump **15***a* arranged to face each other in front and in rear of the vacuum chamber **10**. As illustrated in FIG. **2**B, an ion detection unit **25** is provided in the lower part of the vacuum chamber **10**. Accordingly, in this embodiment, the units are arranged on the five surfaces of the vacuum chamber except the top surface thereof having approximately a rectangular parallelepiped, thus improving the accuracy and realizing the compact size of the mass spectrometer. Further, in this arrangement, because the sample insertion unit **30** to be attached to the vacuum chamber **10** is arranged near the upper surface of the mass spectrometer, the sample insertion port **31** of the sample insertion unit **30** is arranged near the upper surface so as to desirably attach/detach the sample insertion adapter **70** to/from the sample insertion port **31**, as illustrated in FIG. **1**A.

In this embodiment, the heaviest unit is the vacuum pump **15**, and occupies one fourth of the entire weight. In this embodiment, the vacuum pump **15** includes two stages: that are a first vacuum pump (turbo molecular pump) **15***a* to be attached to the vacuum chamber **10** and a second vacuum pump (roughing pump) **15***b* to be attached to the first vacuum pump **15***a*.

In this embodiment, the second vacuum pump (roughing pump) **15***b* is arranged in the front part of the case **100**. In particular, the second vacuum pump **15***b* is arranged to face the first vacuum pump **15***a* arranged in the rear part of the case **100**. This attempts to obtain the weight balance of the case **100** along the front and rear direction.

The second vacuum pump **15***b* is arranged in the lower part of the case **100**, thereby maintaining an arrangement space for the liquid crystal display unit **40** in the upper part thereof. As a result, the sample insertion port **31** of the sample insertion unit **30** is arranged near the liquid crystal display unit **40**. Therefore, the operation unit **120** may be made compact.

Another heavy load may be a battery **20**. In this embodiment, the battery **20** is arranged in the rear part of the case **100** in a position next to the first vacuum pump **15***a* in a side-by-side manner. By so doing, the center of gravity G will slightly be lowered approximately in the rear of the case **100**, that is, in a carriage posture having the handle unit **110**.

A backboard substrate **51** is provided on the bottom surface of the circuit board storage units **60** arranged on both sides of the case **100**. Provided on this backboard substrate **51** are circuit board installation units **52** for aligning the circuit boards **50** in the front and rear direction. According to this configuration, the rectangular circuit boards **50** are put side by side respectively on the circuit board installation units **52**, in the front and rear direction.

As described above, in this embodiment, the circuit boards **50** are processed as parts for adjusting the center of gravity G. Thus, the circuit board storage unit **60***a* on the left side stores a larger number of circuit boards **50** than the number of circuit boards **50** in the circuit board storage unit **60***b* on the right side, and has a larger storage space than that of the circuit board storage unit **60***b*. This is based on the weight and an amount of generated heat of each circuit board and an effect of electric noise.

In this embodiment, a circuit board for controlling electricity are digital circuit board and arranged in the circuit board storage unit **60***a* on the left side near the battery **20**, while an analog circuit board having a high voltage is arranged in the circuit board storage unit **60***b* on the right side.

The above-described layout is applied to the mass spectrometer **1** according to this embodiment. As a result, the center of gravity G may be set approximately in the center along the right and left direction, approximately in the rear part along the front and rear direction, and approximately in the lower part of the vertical direction. With this center of gravity, the center of gravity G is approximately in a lower center position, thus enabling to realize the analyzing process in a stable posture. In the carriage posture in which the handle unit **110** is held with one hand, the center of gravity is the center and slightly in the lower part along the right and left direction of the case **100**, thus enabling to realize the carriage operation. In a normal carriage posture, the spectrometer is held while the operation unit **120** is set in the nearest part to the outer periphery. In other words, the center of gravity may be set in a position near the user side, that is, in a position right below the shoulder of the bearer. Therefore, it is possible to easily carry the spectrometer.

In this embodiment, the blast fan **13** is provided in the rear parts on both sides of the circuit board storage units **60**. However, it is not limited to this configuration. That is, the exhaust systems inside the case **100** include a system for pushing the outside air into the case **100** with the blast fan **13** and a system for taking out the heat inside the case **100** with the blast fan **13**. In consideration of the weight balance, the blast fan **13** may adequately be arranged.

In this embodiment, because the laminar circuit boards **50** can be arranged separately on both sides of the circuit board storage units **60**, the exhaust passage direction Z can be formed along the laminar circuit boards **50**. The heat generated from each unit arranged in the center of the case **100** is taken into the circuit board storage units **60** on both sides so as to be exhausted, thus improving the heat exhaustion efficiency.

The external appearance of the mass spectrometer **1** according to this embodiment will be described with reference to FIGS. **3** to **4**.

In FIG. **3**, the mass spectrometer **1** according to this embodiment is made thin in the form of a business attaché case, and has a compact outer appearance without a bulky body to carry. In the periphery form of the handle unit **110** which is a matter of public exposure in carriage, the pair of projecting units **115** are rounded toward the head end. The projecting units **115** are formed continuously from the box-shaped end parts. The bar-like handle unit **110** is provided to connect the pair of projecting units **115**. Accordingly, a simple configuration without a concave-convex surface is realized with the handle unit **110** introduced into the case **100**. The bar-like handle unit **110** is supported by the pair of projecting units **115**, thus making an appeal to user about the strong configuration.

As seen from the illustration, the outer appearance of the case **100** has a form covered with a thick cover body **113** connecting from the pair of rounded projecting units **115** to the pair of wide surfaces **111** and **112**, with minimized concave-convex irregularities thereon, so as to be easily mounted into vehicles or the like. The periphery of the cover body **113** has corner parts **114** that are rounded, thus reducing the impression of the bulky body. With this appearance, the rain or dusts can easily be wiped out in carriage. Further, the side surface wall **115** of both sides along the width W is lower than the end part of the cover body **113** by one step. Inside that, the exhaust port **150** and an external terminal unit **152** are provided. Thus, the exhaust port **150** and the external terminal unit **152** are unlikely subject to external attacks.

The external terminal unit **152** is covered with the opening/closing cover, in which a non-illustrative main power switch or an external connection terminal is arranged. The external terminal unit **152** is provided adjacent to the circuit board storage unit **60**. Thus, the main power switch or the external connection terminal is directly connected to the circuit boards **50** provided in the circuit board storage unit **60**. Therefore, this configuration does not need new wiring.

In FIG. **3**, the lower part of the case **100**, as the bottom surface, has one down step so as to form a pair of side surface walls **117** in a continuous form, and includes four projecting leg parts **118** on the four corners. As a result, the case **100** can stably be put on the floor, thus preventing the entrance of water into the inlet port **151** formed on this bottom surface, when the case **100** is put on the floor.

Further, the wide surface **112** has the opening/closing cover **121** that is flat with respect to the surrounding wide surface **112**, in a state where the cover **121** is closed as shown in FIG. **3**. On this opening/closing cover **121**, an indicator **153** for indicating "charge" or "power ON" is provided. This indicator **153** is not limited to be provided on the opening-closing cover **121**, but may be provided on the case **100**.

Descriptions will now be made to the operation unit **120** with reference to FIG. **4**. In FIG. **4**, the opening/closing cover **121** of this embodiment has an L-like shape in cross section, has the head end part bent toward the handle unit **110**, and has an opening/closing mechanism **154** on its head end. With this configuration, the opening/closing mechanism **154** is the upper surface in posture of carriage shown in FIG. **3**, thus preventing unintentional operation of the opening/closing mechanism **154**. This minimizes the opening/closing cover **121** kept open in carriage.

In this embodiment, the opening/closing cover **121** is in an L-like form. The opening/closing mechanism **154** has an inclined surface, and includes the display screen **41** arranged thereon. With this configuration, it is possible to improve the visibility and operability of the display screen **41** arranged on the inclined surface (opening/closing cover **154**) and a liquid crystal operation switch **155** arranged in the front part thereof.

In this embodiment, the inclining opening/closing cover **154** is formed on the left front side of the operation unit **120**, and an operation surface **156** is formed along a horizontal surface at the back and right side thereof. A sample insertion port **31** is provided at the back and left side of the horizontal operation surface **156**. An analysis start switch **157** and a sub-main power switch **158** are arranged side by side at the back and right side of the operation surface **156**. A detection lamp **159** is arranged at the right forefront part of the operation surface **156**.

The sample insertion port **31** has an attachment lever **32** for fixing the sample insertion adapter **70** shown in FIG. **1**A. In this embodiment, on the spot of analysis, this sample insertion port **31**, the analysis start switch **157**, and the sub-main power switch **158** are simply operated so as to perform an analysis process. In this embodiment, visible parts, such as the display screen **41** and the detection lamp **159**, are arranged in the front part of the operation unit **120**, while operation parts, such as the sample insertion port **31**, the analysis start switch **157**, and the sub-main power switch **158** are arranged in the back part thereof. In this arrangement, the operation parts can be operated while checking the visible parts, or while acquiring the guidance about the visible parts.

In this embodiment, an adapter preparation unit **160** for preparing a sample insertion adapter **70** is provided using the space between the detection lamp **159** and the analysis start switch **157**. As shown in FIG. **1**A, the sample insertion adapter **70** includes a sample container **71** for putting sample pieces and an attachment case **72** for attaching this sample container **71** to the sample insertion unit **30**.

With this adapter preparation unit **160**, the sample container **70** having the sample put therein is set in a hollow part. The attachment case **72** can be attached downward from up into the stably set sample container **71**. This coupled sample insertion adapter **70** can be attached to the sample insertion port **31**.

The opening/closing cover **121** of this embodiment can be open backward through the hinge **122** which is provided in the rear part of the operation unit **120**. Thus, the internal surface **121***a* of the opening/closing cover **121** is visible to the users. In this embodiment, non-illustrative guidance representing the operation procedures of the mass spectrometer **1** is illustrated on the internal surface **121***a*. In accordance with this guidance, easy operations can be achieved without reading an operations manual.

The use of and operational method of this mass spectrometer **1** will now be described with reference to FIGS. **1**A, B and **5**A to **5**F.

In the mass spectrometer **1**, a non-illustrative control circuit included in the circuit boards **50** generally controls the mass spectrometer **1**. The mass spectrometer **1** is activated upon operation of a non-illustrative main power switch provided on the external terminal unit **152**. Upon operation of the sub-main power switch **158**, the control circuit starts to prepare the operations, and displays a screen **200** on the display screen **41**, as shown in FIG. **5**A

This screen **200** includes a confirmation display unit **201** in the uppermost row, a first status display unit **202** in the second row, a second status display unit **203** in the third row, and a guidance unit **204** in the lowest row. The confirmation display unit **201** shows the analysis date/time and a status of the sample insertion unit **30**. The first status display unit **202** shows the status of examination step. The second status display unit **203** shows guidance additional information and the examination result. The guidance unit **204** shows the operations guidance in written form. No change will be made in the basic layout of the screen **200**. This screen **200** has been described only by way of example, and is not limited to this.

The screen **200** of FIG. **5**A shows the present time, and also shows that no sample has been set into the sample insertion port **30**. The control circuit may display this screen **200**, and also may output voice data stored in a memory unit provided in the circuit board **50**, through a non-illustrative speaker. In this case, the output contents correspond to the guidance on the screen **200**. For example, the user can confirm that the sample can be loaded now, and also that he/she is instructed to load the sample based on the guidance contents and the voice, by watching the screen **200**. Now, the user can understand the operational method based on the guidance screen of the second status display unit **203**.

Upon reception of the screen **200**, the user can set the sample insertion adapter **70** (including the sample container **71** and the attachment case **72** as shown in FIG. **1**A) to the sample insertion port **31**, and executes an operation for fixing the adapter by operating the attachment lever **32**.

The control circuit displays the screen **210** shown in FIG. **5**B, upon detection that the sample insertion adapter **70** is set to the sample insertion port **31** by operation of the attachment lever **32** based on a non-illustrative sensor. This screen **210** shows the guidance that the sample insertion adapter **70** can be taken out now, informs that it is possible to perform measurement, and instructs the user to press the start button. In this status, the control circuit starts the analyzing when the analysis start switch **157** is operated.

The control circuit displays the screen **220** shown in FIG. **5**C, when the analysis start switch **157** is operated. This screen **220** shows that the sample insertion adapter **70** cannot be taken out, and shows also the remaining detection time. Upon detection of one kind of target material, the control circuit displays the screen **230** shown in FIG. **5**D. Upon detection of several kinds of target materials, the control circuit displays the screen **240** shown in FIG. **5**E. When no target material has been detected, the circuit displays the screen **250** shown in FIG. **5**F.

On the screens of FIGS. **5**D and **5**E, the control circuit outputs a voice signal for informing that the target material has been detected, or informs the user about the detection of the target material by flashing or turning on a specific light of light on the detection lamp **159**. This specific color represents the detection of a target material. Similarly, if no target material has been detected, the control circuit outputs the same voice signal together with the screen of FIG. **5**F, and turns on or flashes another specific color of light on the detection lamp **159**.

In each of FIGS. **5**D to **5**F, the screen shows the guidance for instructing the user to take out the sample insertion adapter **70**, upon complete examination. Then, the control

circuit displays the screen **200** of FIG. **5**A, when it is detected that the sample insertion adapter **70** has been taken out, upon user operation of the attachable lever **32**.

Another Embodiment

Another layout of the operation unit will now be described with reference to FIGS. **6**A and **6**B.

FIG. **6**A shows a layout of another embodiment, in which the operation unit **120** is divided into two parts left and right. One divided part includes the sample insertion port **31**, which needs to be covered with the opening/closing cover **121**, and sub-main power switch **157** related to this sample insertion port **31**. The other divided part includes the display screen **41**, the detection lamp **159**, and the sub-main power switch **158**. This embodiment is suitable when a large display screen **41** is applied. Even if the opening/closing cover is not open, the display screen is operable with using the liquid crystal operation switch **155**. Therefore, unnecessary exposure of the sample insertion port and/or analysis start switch can be prevented, at the operations the maintenance or at the confirmation of analysis history.

In the embodiment of FIG. **6**B, the analysis start switch **157** and the sub-main power switch **158** are arranged in the front part of the operation unit **120**, while the sample insertion port **31** is arranged in the rear part of them, and further the display screen **41** is arranged compact in the rear part of that. This embodiment is suitable for the operation unit of a further compact mass spectrometer. The display screen may be arranged in the rear part of the sample insertion port. In other words, the screen is kept away from the user. In this arrangement, even if a solution is unexpectedly spilt when the sample insertion adapter **70** is inserted into the sample insertion port, the possibility that the spilt solution reaches the display screen may be reduced.

Accordingly, the mass spectrometer of this embodiment includes the case and circuit board storage units on both sides of the case. Inside the case, heavy loads are arranged in the center thereof, and include the vacuum chamber, the vacuum pump, the sample insertion unit, and the ion detection unit. Specifically, the vacuum pump evacuating air from the vacuum chamber. The sample insertion unit provides ionized sample into the vacuum chamber. The ion detection unit is connected to the vacuum chamber. Each of the circuit board storage units stores plural circuit boards.

In this case, the case has the height larger than its width and the depth smaller than the height. The above-described circuit board storage units are provided on both sides along the width direction. The plural boards arranged inside the circuit board storage units are aligned along the height direction. Further, each of the circuit board storage units includes exhaust/inlet ports at both terminal ends along the height direction.

In the mass spectrometer of this embodiment, a case has heavy loads including a vacuum chamber, a vacuum pump evacuating air from the vacuum chamber, a sample insertion unit for providing ionized sample into the vacuum chamber, and an ion detection unit connected to the vacuum chamber, in the center thereof. Exhaust passages for exhausting heat generated from the heavy loads are formed on both sides thereof, and plural circuit boards are separately stored along the exhaust passages.

In this case, the case has the height larger than the width, and has the depth smaller than the height. The exhaust passages are formed on both sides along the width direction. The plural boards arranged inside the exhaust passages are aligned along the height direction. Further, the exhaust passages include the exhaust/inlet ports on both side ends along the height direction.

In the mass spectrometer of this embodiment, the case having a height smaller than a width and having a depth smaller than the height centrally have: heavy loads including a vacuum chamber; a vacuum pump evacuating air from this vacuum chamber; a sample insertion unit which provides an ionized sample to the vacuum chamber; an ion detection unit which is connected to the vacuum chamber; and a battery, wherein circuit board storage units for separately storing plural circuit boards are formed on both sides along a width direction, both ends of the case including the pair of circuit board storage units have a pair of projecting units which project in one height direction and are connected with a bar-like handle unit, and widest surface of the case has an operation unit including an injection port for injecting a sample into the sample insertion unit.

In this case, the circuit board storage unit is an exhaustive passage along which the plural circuit boards are aligned along the height direction, and includes an exhaust/inlet port on both ends along the height direction. Further, the operation unit is covered with the opening/closing cover, and includes a driving status display unit and an examination start button.

What is claimed is:

1. A mass spectrometer, comprising:
a case;
a first circuit board storage unit; and
a second circuit board storage unit,
wherein the first circuit board storage unit is disposed on one side of the case and the second circuit board storage unit is disposed on an opposite side of the case,
each of the first circuit board storage unit and the second circuit board storage unit store a plurality of circuit boards,
the case centrally having heavy loads disposed inside the case and between the first circuit board storage unit and the second circuit board storage unit,
the case centrally having heavy loads including:
a vacuum chamber;
a vacuum pump which evacuates the vacuum chamber;
a sample introduction unit which introduces and evaporates a sample to be measured;
an ionization unit which ionizes the evaporated sample, and provides the ionized sample to the vacuum chamber; and
an ion detection unit which is connected to the vacuum chamber.

2. The mass spectrometer according to claim **1**, wherein
the case has a height smaller than a width, and has a depth smaller than the height,
the circuit board storage units are provided on both sides along a width direction of the case.

3. The mass spectrometer according to claim **2**, wherein
the plurality of circuit boards arranged in the circuit board storage units are aligned along a height direction.

4. The mass spectrometer according to claim **2**, wherein
each of the circuit board storage units includes exhaust/inlet ports on both ends in a height direction of the case.

5. The mass spectrometer according to claim **1**, wherein
an exhaust passage is formed in both of the circuit board storage units.

6. The mass spectrometer according to claim **5**, wherein
the case has a height smaller than a width, and has a depth smaller than the height; and
the exhaust passage is provided along the width direction on both sides of the case.

7. The mass spectrometer according to claim 6, wherein the plurality of circuit boards arranged along the exhaust passage are aligned along a height direction.

8. The mass spectrometer according to claim 6, wherein the exhaust passage includes exhaust/inlet ports on both ends along the height direction of the case.

9. A mass spectrometer, comprising:

a case having a height smaller than a width, and having a depth smaller than the height;

wherein heavy loads are arranged centrally inside the case, the heavy loads include:

a vacuum chamber,

a vacuum pump which evacuates the vacuum chamber,

a sample introduction unit which introduces a sample to be measured and evaporates the sample,

an ionization unit which ionizes the evaporated sample and provides it to the vacuum chamber, and

an ion detection unit which is connected to the vacuum chamber;

wherein a circuit board storage unit is formed on each side of the case in a width direction of the case, with a predetermined space therebetween, the circuit board storage units store a plurality of circuit boards

wherein the circuit board storage units on each side of the case have projecting units which project toward a height direction,

wherein a bar-like handle unit is formed to connect each of the projecting units, and

wherein an operation unit includes an injection port for injecting a sample into the sample introduction unit, which is formed on a widest surface of the case.

10. The mass spectrometer according to claim 9, wherein each of the circuit board storage units includes an exhaust passage along which the plurality of circuit boards are aligned in the height direction, and includes an exhaust/inlet port on each of both ends along the height direction of the case.

11. The mass spectrometer according to claim 10, wherein the operation unit is covered with an opening/closing cover, and includes an operation status display unit and an examination start button.

12. The mass spectrometer according to claim 9, wherein a rotating body is included in the vacuum pump; and

the vacuum pump is arranged so that a rotating shaft of the rotating body inside the vacuum pump is in a horizontal direction or a vertical direction when the spectrometer is held up with holding the handle unit.

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